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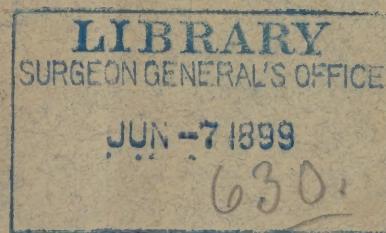
THE INTIMATE NATURE OF TUBERCULOSIS;
ITS TRANSMISSIBILITY, AND
ITS PARASITIC ORIGIN

BY

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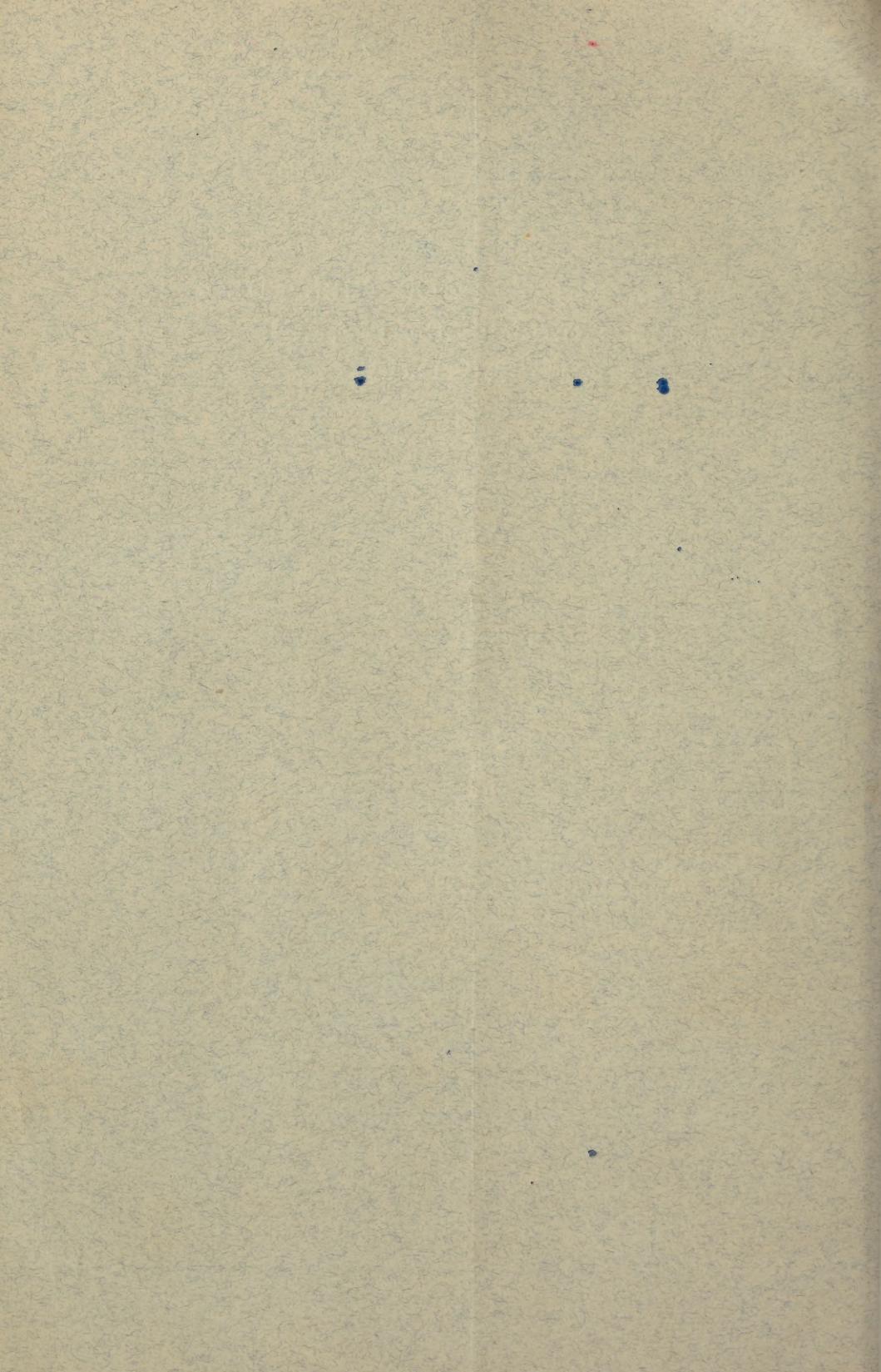
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THE INTIMATE NATURE OF TUBERCULOSIS;
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BY C. HEITZMANN, M.D.,

NEW YORK.

THE human mind is not prone to change opinions and doctrines supposed to have been settled by the teachings of authorities. When, in 1873, I contradicted the cell-theory, I did not expect an immediate acceptance of the new view concerning the construction of the animal body; the less, as these views were based upon researches requiring unusually well-trained eyes and unprejudiced judgment. More especially in microscopy, a great many imagined discoveries and views, in the last forty years, have been proved false; and, as a rule, but a very brief period was required to show how unworthy they were of acceptance. My own views and discoveries, on the contrary, have very gradually gained ground during the last nine years. The discovery of the reticular structure of so-called "protoplasm" was, at first, ignored; but as early as 1878 E. Klein enumerated over a dozen good observers who recognized the reticulum partly in preserved, partly in living "protoplasm," and this number has considerably increased since. In 1880, S. Stricker, known to be the best micro-

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scopist abroad, described the reticular, or trabecular structure in live saliva-corpuscles, and the form-changes of the trabeculæ, which are explicable only by admitting that they are formations of living matter. In my own laboratory I have had no difficulty, after the eye had been trained to see such delicate features, in demonstrating the presence of a reticular structure of amœboid corpuscles. Besides the saliva-corpuscles, I found the living blood-corpuscles of the crab of service. We obtain these by breaking off a limb of the animal, and transferring a droplet of the oozing liquid to the slide, covering the specimen with a thin covering glass, the edges of which have been previously oiled to prevent evaporation of the liquid.

S. Stricker, in 1880, also announced that in the cornea there exist no wandering and no isolated cells; that under favorable conditions we can observe the direct transformation of "basis-substance" into "protoplasm," and of "protoplasm" into "basis-substance." The preliminary publication of this subject I have translated and printed in my "Microscopical Morphology," because it plainly shows the coincidence of Stricker's views with my own, which I had published seven years previously. I lay stress upon Stricker's assertions, as he is known to be an extremely skilled microscopical observer, in contradistinction to the scores of microscopists who look into the instrument without ever becoming conscious of what they see. Quite recently, however, S. Stricker, in a public lecture delivered before his class, and printed in the *Wiener Medizinische Blätter*, Dec., 1882, announces that my assertions, regarding the life of basis-substance, were based upon the study of very clear and satisfactory specimens, which he himself had seen in 1873. Nevertheless, he needed six years' labor to be fully convinced of the correctness of my assertion that the basis-substance is really endowed with properties of life, equally

with the so-called "protoplasm." Stricker adds that the old-established theory, "*Omnis cellula e cellula,*" must now fall to the ground.

Thus the most reliable observer abroad has corroborated my second statement, made in 1873, that in the animal body there exist no isolated "cells" within the tissues; that both the "cells" and the intercellular, or basis-substance, are pervaded by an extremely delicate reticulum of living matter, which at once comes to view if the glue-yielding portion of the basis-substance is liquefied, or, as Stricker calls it, is "*disgregated.*" The method of A. Spina, published in 1879, furnishes us with a ready means of demonstrating the connections of the cartilage-corpuscles by delicate offshoots traversing the basis-substance. We simply place fresh cartilage in strong alcohol, cut the specimen in alcohol, and mount it in the same liquid. Specimens obtained by this method are so clear that any tyro can convince himself to-day of the correctness of the discovery which I made in 1872, that all cartilage-corpuscles are uninterruptedly connected with each other, and the basis-substance is pervaded by living matter but slightly less in amount than that in the cartilage-corpuscles themselves.

Based upon these researches, I have contradicted the cell-theory. Instead of assuming with R. Virchow that the animal body is a colony of individual cells, I have maintained that it is one continuous mass of living matter, mostly in a reticular arrangement; and that the difference in the tissues rests only upon the chemical and physical nature of the substance filling the meshes of the reticulum. I compared the highly-organized body of a mammal with a large amœba, in which the granules of living matter at the points of intersection are developed into what previously had been termed "cells." As in the amœba, there appear temporarily closed spaces, filled with liquid and con-

taining isolated granules of living matter; so the body of the mammal is traversed by closed spaces, known as blood- and lymph-vessels, in which, in a liquid, are suspended isolated corpuscles, the blood- and lymph-corpuscles. As soon as these facts and conclusions are approved and received, the cell-theory will be overthrown, for the individuality of the cell, upon which the cellular physiology and pathology mainly rested, will be destroyed. I bring these corroborations before the public in order to abolish the mistrust with which my assertions have been regarded for the last nine years. There are further statements of mine which, outside of my laboratory, have not yet been received. These, however, in a time not far distant, must meet with the approval of scientists, inasmuch as they are the results of direct observation, and are as well supported as the facts concerning the structure of single elements and that of the interstitial substances. I here allude to the constitutional differences in the aspect of single elements, their difference according to the amount of living matter present in the whole organism; upon which, as I shall presently demonstrate, rests the doctrine of the constitutional nature of different diseases, more especially of tuberculosis and scrofulosis.

With the new views concerning the construction of the animal tissues, the phenomena of inflammation are easily understood. It is quite interesting to note from the history of the doctrine of inflammation, how closely it was connected with and dependent upon the biological views for the time considered correct. The original views of humoral pathology, that inflammation is a disturbance of the vascular system mainly, and that the inflammatory elements, including pus-corpuscles are products of the exudate, yielded to the cellular pathological views. By the latter no stress was laid upon the part taken by the blood and the blood-vessels.

The whole process of inflammation was considered to start and run its course in the tissue-elements, the "cells," which alone were thought to be endowed with life, and by their proliferation and multiplication should have produced the vast amount of inflammatory or pus-corpuscles visible in an inflamed tissue. This theory originating with Virchow, was contradicted by Cohnheim, who considered the inflammatory infiltration, the accumulation of pus-corpuscles, to be due only to an emigration of colorless blood-corpuscles, so-called "leukocytes," while the mother tissue and its constituent elements perished altogether. In the latter view, upheld even in our days by a number of German pathologists, nothing was alive in the body except the colorless blood-corpuscles, and it was only upon irritation that they would react by their emigration from the capillaries and small veins. An untenable view surely, but one which, if correct, would save us the trouble of studying the minute anatomy of tissues which were about to perish and disappear in a mass of colorless blood-corpuscles.

S. Stricker deserves credit for having, since 1870, strenuously opposed the assumptions of Cohnheim. Stricker proved that in all the previous ideas concerning the process of inflammation there was some truth, but that only in the combination of these theories full truth was to be found. He demonstrated the necessity of the presence of blood-vessels and nerves for the inflammatory tissue; he proved the correctness of Virchow's assertion concerning the proliferation of the tissue-elements and their offshoots, without endeavoring to deny that in certain forms of the inflammatory process an actual emigration of colorless blood-corpuscles takes place. He proved the correctness of the hypothesis of John Hunter, that inflammation essentially consists in a recurrence of the juvenile condition of the tissues. Since 1880, Stricker has advanced a step farther, and now re-

ceives my statement that at first a mere liquefaction or disintegration of the basis-substance takes place, leading, in a comparatively short time, to a reappearance of the living matter previously concealed therein. Recently he even ascribes the apparent amoeboid motion of "protoplasmic bodies" in the inflamed tissues to a rapid dissolution and re-formation of the basis-substance.

In 1873, I stated that in inflammation of the connective-tissue varieties at first a liquefaction of the basis-substance occurs, whereupon the medullary or embryonal elements, which originally shared in the formation of the basis-substance, simply reappear. Where before was visible only a central corpuscle, surrounded by a certain amount of basis-substance in the shape of a territory, after the dissolution of the latter a number of elements make their appearance, not being newly formed, and not being due to the proliferation of the central corpuscle, but simply made visible by a change in the refractive power of the formerly solid, and afterward liquid, interstitial substance. A real new-formation of inflammatory elements takes place in the course of the inflammatory process by an increase of the amount of living matter of the medullary corpuscles, starting not only from the central nuclei, but from any granule of living matter, *i. e.*, any point of intersection of the reticulum of living matter. Thus the original connective tissue is replaced by, and transformed into, inflammatory corpuscles, the sum total of which furnishes the condition known as the inflammatory infiltration. I further maintained, that at first all the newly appearing and newly formed elements remain connected by means of delicate thread-like offshoots, and that the tissue, although greatly changed, does not cease to be a tissue. So long as no new elements have been formed, an immediate re-formation of basis-substance may take place, and the inflammatory process terminate in

the shortest and most perfect way, by what is known to the pathologists as "resolution." After a large number of inflammatory corpuscles have formed, a reëstablishment of basis-substance may occur; but the bulk of the inflamed tissue being augmented, the result would be hypertrophy or hyperplasia. Thus the anatomical foundation of the termination of inflammation was discovered, for the general designation of which the term "plastic" or "formative" was long since adopted by the pathologists and clinicians.

If, on the contrary, the mutual connection of the inflammatory elements be destroyed, perhaps merely mechanically by the exudation, the broken elements themselves will be suspended in a serous liquid, and will furnish the substance for the pus-corpuscles. Pus, we know, is no tissue; pus, I said, is a broken-down, disintegrated tissue, and the pus-corpuscles are, in the main, products of the inflamed tissue itself. The difference between inflammatory elements, constituting a tissue, and those composing an abscess has not yet been recognized by Stricker, who believes all inflammatory corpuscles to be pus-corpuscles.

In epithelial tissue the process of inflammation runs a very similar course. In single epithelia, provided they still possess the properties of life, by an increase of the living matter, new inflammatory corpuscles arise in a manner, known since Remak as the endogenous new-formation. Should the newly formed elements wander actively from their place of origin, or be thrown out by active contraction in the unchanged living matter within the epithelial body, each newly formed element will represent a pus-corpuscle, and its previous location within the epithelium be marked by a so-called vacuole. Coalesced epithelia, in which the cement-substance has been liquefied, may give the aspect of multinuclear bodies, and subsequently divide into medullary or inflammatory corpuscles, fully identical with those

sprung from connective tissue. Doubtless such medullary corpuscles may be supplied with, or transformed into, basis-substance, and furnish newly formed, usually fibrous, connective tissue, the shrinkage of which causes the diminution of the bulk of glandular organs, for instance of the liver, the kidneys, in the process known as "cirrhosis" of these organs. The epithelia are destroyed by the production of inflammatory corpuscles, which, so far as the new-formation of a cicatricial, dense connective tissue is concerned, do not differ from inflammatory corpuscles arisen from the original, interstitial connective tissue.

The blood-vessels, present only in connective-tissue formations, deserve special attention. We know, mainly through Stricker's researches, that they were originally solid cord- or club-like formations, which later, by vacuolation, become hollowed out, their walls being differentiated into endothelia. In avascular tissues which greatly surpass in bulk the cornea, or in tissues very scantily supplied with blood-vessels, such as the fully developed cartilages, no inflammation can be brought about, even after the most intense irritating agencies, such as red-hot iron. In vascularized tissues, higher degrees of the inflammatory process lead, at a certain stage, to a destruction of a large number of blood-vessels. This process of destruction is, in all essential features, a rejuvenescence of the vessels, *i. e.*, they are first transformed into solid cords and afterward split into inflammatory elements, identical with those which arise from the surrounding connective tissue. Every tissue invaded by inflammation of a higher degree assumes, in an advanced stage of the inflammation, a pale gray color, owing to the lack of blood-vessels. As soon, however, as the inflammation abates, a re-formation of the vessels takes place, either equalling the normal supply of the tissue, or in a number smaller than that of the healthy tissue. The latter feature

is observable mainly in hyperplastic or hypertrophied tissues, and in the cirrhotic condition of glandular organs, the result of subacute inflammation. Hyperplastic, cirrhotic, and cicatricial connective tissues, as a rule, are but scantily supplied with capillary blood-vessels.

Should the newly-formed inflammatory corpuscles break apart, become isolated, and in consequence cease to be a tissue, the result will be an abscess, wholly destitute of blood-vessels. The sequence will be the same, whether the corpuscles originated from connective tissue and former blood-vessels, or from epithelia. Around the pus-filled cavity, owing to a reactive inflammatory process, a new formation of connective tissue takes place, in some instances freely, in others, scantily provided with blood-vessels. This constitutes the wall of the abscess, and was formerly described as the *membrana pyogena*, but is under all circumstances a secondary formation following the appearance of the abscess.

Observation shows that a re-formation of blood-vessels after an inflammatory process occurs only in otherwise healthy persons, of a good constitution ; persons, therefore, whose body contains a large, or at least fair amount of living matter. The blood-vessels being originally bulky, solid cords of living matter, obviously an outgrowth of this matter, sufficient for the production of blood-vessels, can take place only in an organism richly supplied with living matter. Persons, on the contrary, of a weak constitution, being provided with but little living matter in their organism, are unfit for the reproduction of vessels lost in the process of inflammation. Such individuals are termed tuberculous or scrofulous. Whenever an inflammation sets in in any organ of the body, oftentimes depending upon trifling irritations, the so-called catarrhal processes, the course taken by this morbid process is the same as in persons of a good con-

stitution, with this exception only, that the lost blood-vessels are not re-formed. Consequently the inflammatory foci, deprived of their nourishing vessels, will be composed of shrivelled elements, which later break apart, become disintegrated, and assume a yellow color, becoming crumbly and friable; in short, take on the condition known under the term "cheesy," and thus represent a disintegrated tissue, for the general designation of which the word "tubercle" is used. Tubercle, therefore, is the result of an inflammatory process, in the course of which the blood-vessels of the inflamed tissue have been destroyed and never re-formed. Tubercle is an avascular product of inflammation. As the process is precisely the same as in the formation of an abscess, only of a very much lower grade and slower course, the designation of the tubercle as a *dry abscess* seems to be fully appropriate. It makes no difference what variety of vascularized tissue was the original seat of inflammation, the result will always be the same. We know that catarrhal inflammation of the lungs leads most frequently to the formation of tubercles, but the same process occurs quite frequently in serous and mucous membranes, also in the latter case with a rapid destruction of the cheesy foci in the shape of ulceration. Bony tissue is known to be often the seat of cheesy foci as the result of osteitis, establishing the condition clinically known as caries. In the skin such cheesy foci constitute the disease designated lupus, etc. The lymph-tissue, bearing also the misnomer "adenoid tissue," being, in its follicular formations, especially scantily supplied with blood-vessels, is likewise extremely prone to inflammation and the production of cheesy foci, generally termed scrofulous. These formations, although differing in their clinical aspect from tuberculosis of other organs, nevertheless are fully identical with tuberculosis. In fact, there is no vascularized tissue in the organism enjoying an

immunity from tuberculosis, and as it is the connective tissue exclusively which holds blood-vessels, the issue of the inflammatory process will, under all circumstances, be connective tissue. In this view of the process of tuberculosis the tubercle ceases to be a "deposit" in the sense of Laënnec and the humoral pathological school, but is an inflammatory infiltration of a vascularized tissue deprived of its blood-vessels. The tubercle thus will be deprived of all specificity, and will be regarded as a purely constitutional disease.

The process of tuberculosis, although starting with the erroneous view, that it consists in a "deposition" from the blood, was accurately described by Rokitansky. With him the endless varieties in the manifestations of the disease were mainly due to the time required for the development of tubercles, viz., whether the process ran a slow, chronic course; or a chronic course with more or less frequent acute recurrences, the subacute form; or, lastly, an acute form, consisting mainly in the appearance of minute, so-called miliary tubercles. My own researches, based upon the examination of three hundred bodies of persons dead of tuberculosis, were in full harmony with the conception of Rokitansky.

In the lungs tuberculosis appears as a chronic, a subacute, and an acute disease. The chronic or, preferably, localized tuberculosis of the lungs is situated usually at the apices, and consists of scattered inflammatory foci of moderate size, around which, owing to a reactive inflammation, new, dense connective tissue is formed, resulting in the induration, or cirrhosis, of the lung-tissue. The size of the original tubercles is certainly of less consequence as to the sequelæ of the process; it is mainly the number of the foci, and the lack of recurrent formations of tubercles, which determine the degree of the subsequent induration of the lung-tissue. This form is specially prone to heal either by obsolescence,

the new-formation of a basis-substance within the avascular tissue of the tubercle, or by fatty degeneration and deposition of calcareous matter in the tubercle. Observation plainly demonstrates that a genetic separation of the tuberculous nodule from the tuberculous infiltration is not admissible; that the later metamorphoses depend materially upon the circumstance whether or not the nodule or node remained a tissue. Further, we see that the possibility of an inflammatory focus becoming callous, depends greatly upon its size, and that the solidification of the lung-tissue may take place either by the formation of a circumscribed capsule, or as a diffuse induration, all of these being secondary occurrences. The second form of tuberculosis of the lungs is the subacute or dispersed tuberculosis, characterized by continuous recurrences of tubercles, even in an already formed connective-tissue capsule, and simultaneous exudation into the older cheesy focus, and ulceration of the invaded tissue. Here we are again satisfied that there is no essential difference between a nodule and an infiltration, for either may be transformed into a crumbly mass and become softened. The ulcerative destruction of the lung-tissue is different merely in its acuteness, that is, according to whether a number of scattered nodules are breaking down at different times, or whether an infiltration is continually softened and simultaneously increasing in size at its periphery. The surrounding lung-tissue, in all forms of softening and local necrosis, is evidently involved only in a secondary manner, therefore is in a reactive, acute, or chronic, inflammation. A third form of tuberculosis of the lungs is known by the name of the acute or miliary tuberculosis, consisting in a nearly simultaneous formation of innumerable nodules, the size of a millet-seed, or even less, throughout the entire lung-tissue, and in other organs. This form was especially attributed to the presence of a cheesy focus,

either in the lungs, in lymph-ganglia, or any other part of the body, whose contents being taken into the vascular system, would produce innumerable small foci of tuberculosis, in an embolic manner. My own observations, however, fully coincide with those of Buhl, that in ten per cent. of cases of general miliary tuberculosis, which almost invariably terminate fatally in a comparatively short time, no cheesy focus whatever can be discovered in the organism. A fourth variety of tuberculosis occurs in the lungs in the form of tuberculous pneumonia, starting with the features of an ordinary lobar or croupous pneumonia, with subsequent destruction of all blood-vessels in the inflamed portion of the lung, and transformation of such portions into a half-dry, cheesy mass.

Microscopical examination of tuberculous lungs in any one of the above-described varieties demonstrates their complete identity in the minute anatomical features. All of them at first exhibit the features of catarrhal pneumonia, an infiltration of the walls of the alveoli with inflammatory corpuscles, an engorgement of the alveoli with such corpuscles, and a few unchanged, or slightly changed epithelia; the presence of a serous or albuminous exudation, and the extremely small amount, or entire absence, of coagulated fibrine. The most striking feature, in all instances, is the lack of blood-vessels, and to such an extent, that although in all forms the tubercle is surrounded by vessels, some of which may penetrate its most peripheral portions, the mass of the tubercle is completely destitute of vessels. This feature, under the microscope, at once enables us to tell positively whether or not a tubercle is before us, in the lung-tissue, as well as in any other part or tissue of the body. The breaking down of the walls of the alveoli is, as a rule, so complete, that only a frame of elastic fibres is left as an indication of the former alveolar wall. These fibres, in a sub-

sequent softening process of the tubercle, may be eliminated with the sputa and appear under the microscope, furnishing positive proofs of an ulcerative destruction along the aërial passages; together with shrivelled and disintegrated inflammatory corpuscles, if the ulcerative process be tuberculous in nature.

The process of tuberculosis in the lymph-ganglia is of the same nature. Here it likewise appears, either as a diffuse infiltration of the ganglion, if the original inflammation has invaded the ganglion *in toto*, or as small circumscribed infiltrations, never, of course, nodules (*tubercula* in the proper sense of the word), if the inflammatory foci were from the beginning disseminated. Should the tuberculous focus be softened by secondary inflammation of the surrounding vascularized tissues, an abscess will form, which breaking open or being cut into, yields the characteristic serous pus, with intermixed cheesy flakes and crumbs. Subsequently ulceration takes place in and over the tuberculous lymph-ganglion, with the characteristic features of a "scrofulous" ulcer, running a markedly slow course, and terminating in the production of an extensive, irregular, pigmented scar. Although scrofulosis is a prevailing disease of childhood, and persons prone to scrofulosis in their youth sometimes remain exempt from tuberculosis of the organs, yet the process must be considered as identical with tuberculosis, both from the pathological and microscopical appearances.

From my description, it plainly follows that I draw no essential distinction between tuberculous infiltration and a tubercle nodule, both being the products of an inflammation. This is contrary to the views held by Virchow, who considered the chronic and subacute form of tuberculosis of the lungs as the result of inflammation; the miliary tubercles, on the contrary, as the products of a new-formation,

a sort of tumor, composed of granulation-tissue. He originated the idea that chronic tuberculosis of the lungs is only cheesy pneumonia, while the miliary tubercle is the tubercle proper, being really a tubercle in shape. Niemeyer, later, perfected this theory into a clinical doctrine, according to which a person with cheesy pneumonia, whose lungs are in part in the condition of induration and cirrhosis, in part ulcerated and destroyed—individuals, therefore, suffering from phthisis—might become tuberculous, *i. e.*, attacked by acute miliary tuberculosis. Most of the clinicians have, without further discrimination, accepted this unscientific theory, being very much afraid lest patients with chronic or subacute cheesy pneumonia might become tuberculous. That such views do not stand the proofs of pathological research is obvious ; and to-day pathologists begin to return to the old-fashioned and for a time abandoned views, that all forms of tuberculosis are, in the essentials, identical.

In my conviction, tuberculosis is a thoroughly constitutional disease, the features of which are marked in the individual from birth to the end of life : the pale complexion, the tall frame, the narrow chest, the ill-developed muscles, the small heart, the thinness of the arteries, the ease with which hemorrhage takes place, for instance, frequent bleeding from the nose, chlorosis, and a number of other features, are well known to all practitioners. It is further known that such individuals show a very marked tendency to slight so-called catarrhal processes, mainly in the mucous membranes of the nasal, pharyngeal, laryngeal cavities, the bronchial tubes, the lungs, the stomach, and intestines. So-called colds, catarrhal inflammation of the aërial passages, and diarrhoea are the most common occurrences, and the lymph-ganglia within the range of the inflamed tissue are extremely prone to swell, and eventually become tuberculous, or, as the clinical expression says, “ scrofulous.”

After I had discovered the fact that the delicate reticulum within each single element, constituting the organism, is the living matter proper, greatly varying in amount in different individuals, I turned my attention more particularly to the appearance of the living matter in pus- and colorless blood-corpuscles and their relation to the general constitution of the individual, as ascertained by the characteristic appearance to the naked eyes and by reliable family histories, obtained mostly from intelligent physicians who attended my laboratory. After several years of careful observation, the fact became settled in my mind that the marked differences observed in the appearance of the above-named corpuscles under the microscope were in accordance with the constitutional features of the persons who furnished these corpuscles.

Obviously, what we call a good constitution, depends upon the presence of a large amount of living matter in the bulk of the body; on the contrary, what we call a poor, tuberculous, phthisical, or scrofulous constitution, is due to a deficiency of living matter. Pus- or colorless blood-corpuscles, formed in a person of an excellent constitution, will, under the microscope, appear homogeneous or nearly so, indicating that these corpuscles contain a large amount of living matter. No nucleus, and scarcely any structure, is discernible in such corpuscles. Coarse granulation of the corpuscles, *i. e.*, large points of intersection with short indistinctly marked threads connecting the granules, are features of a good constitution; the nucleus, likewise a formation of living matter, may be invisible in such corpuscles, owing to their coarse granulation, or be present in the shape of a solid lump, without a frame in its interior, and without a nucleolus. A middling constitution is marked by less coarse points of intersection in the body of the corpuscle and by a homogeneous or coarsely granular nucleus; the reticulum will, in

such corpuscles, be easily recognizable with the microscope. A poor constitution will become evident if a corpuscle be, with lower powers of the microscope, finely granular, with higher powers distinctly reticular, and exhibiting a very distinct nucleus, enclosed by a well-marked shell, and having in its interior a few coarse granules, all inter-connected by means of delicate filaments. Living corpuscles of the latter variety will, under suitable conditions, exhibit the most active changes of form and locomotion, and by intense contractions of the reticulum easily burst and become disintegrated and form into clusters of granules, more especially upon the approach of death.

As to the extremes described in pus- and colorless blood-corpuscles, there can be no doubt left. The innumerable shadings between the best and the poorest corpuscles, of course, admit of different interpretations according to the acuteness of vision of the observer and his clinical experience. I have repeatedly urged upon intelligent practitioners to take these features into earnest consideration, as I myself have no opportunity for testing them in hospital practice. Should all views prove to be correct, as laid down in my recently issued work, "Microscopical Morphology," we would unquestionably obtain, for the first time, an anatomical foundation for our clinical work.

The views, upon which, up to our day, rested the explanation of different diseases in different individuals, were unsatisfactory enough. Humoral pathology suggested for this purpose the "dyscrasia," which meant a "bad mixture" of the liquids of the body, particularly of the blood. Every disease was based upon a certain dyscrasia. We have even at present so little positive knowledge of the chemistry of the blood, that Virchow's attempts to abolish the theory of "dyscrasia" may be considered perfectly legitimate. Virchow himself replaced the "dyscrasia" by the "diathesis,"

which had no bearing upon the liquids, but only upon the tissues, more especially the "tissue-cells," considered at that time as the only seats of life. In Virchow's definition the "diathesis" meant a certain vulnerability, a certain debility of the tissue, a certain lack of resistance against injuries, etc.,—a thoroughly hypothetical assumption for which there existed no anatomical foundation whatever. It was very easy to explain the cause of diseases by a certain "diathesis," and this explanation was fashionable during the last thirty years, sparing the physician all further trouble of research and thought. As the "diathesis" seemed so unsatisfactory, Virchow himself was forced to resort to another explanation, which he termed "predisposition." Anybody might acquire a disease in consequence of a pre-existing "disposition" to it, and when he dies, he dies because he was disposed to die. "Predisposition" was employed to account for many different pathological processes, but upon second sober thought we must admit that it did not explain any thing.

When I discovered the constitutional differences by the aspect of single elements of the organism, traceable not only in those of the normal and pathological liquids, the colorless blood- and pus-corpuses, but likewise in those of the different tissues, I thought that for the first time something positive was offered for the explanation of the etiology of diseases, something within our grasp, something that everybody could see and deal with as an anatomical feature. "Dyscrasia," "diathesis," "predisposition," I thought, should be put together in one category, and altogether discarded, although they had been representatives of medical wisdom for centuries.

I found that even the degree to which the organism was lowered in its constitutional amount of living matter could be told by watching pus-corpuses, for instance, in urine. If

an originally good constitution was present but broken down by some chronic ailment, in addition to the coarsely granular pus-corpuscles, finely granular ones were invariably present ; the more finely granular and the more numerous, the more the individual was debilitated. I thought that emaciation of the body, loss of strength, and the like, directly rested upon a waste or loss of the living matter, as shown by the pus-corpuscles. All this is sketched only in rude outlines, and very hard conscientious work is yet required before we will be justified in basing positive statements concerning the relation between the appearance of single pus-corpuscles and constitutional ailments. Should this ever be accomplished, no doubt we would gain firm ground for a medical achievement far surpassing in value the so-called 'curing' of diseases, namely, their prevention.

Observation shows that all elements involved in the formation of a tubercle are finely granular, *i.e.*, scantily supplied with living matter. So long as the inflammatory new-formation is going on, we not infrequently meet with a few elements showing a somewhat coarser granulation, particularly epithelia in endogenous new formation. There are seen also small lumps of living matter, compact and homogeneous, the first appearance of newly-formed elements, which afterward grow into vacuoled, and finally into nucleated, corpuscles. Such lumps, however, are few in comparison with the large number of bulky globular formations, having the aspect of "haemato blasts," filling the inflammatory focus in persons of an extraordinarily good constitution. If we examine pus-corpuscles in the urine of individuals with a marked phthisical taint, we will see none but such as are finely granular, distinctly nucleated ; and in a droplet of blood, taken from a minute prick of the skin of such an individual, only finely granular bodies will be met with, all of them being but scantily supplied with living

matter. From this observation we must conclude that either tuberculosis is a purely constitutional disease, or, if such a thing as a directly inoculable virus of tuberculosis exists at all, it finds a favorable soil for development only in individuals of a poor constitution.

The next question for our consideration must be, Is tuberculosis an infectious, transmissible disease? This question can be answered in two ways, viz.: by clinical observation of physicians, and by experiments made on animals. In neither way has there been obtained a definitive or conclusive answer. In my laboratory I meet with many bright physicians, considered as unprejudiced observers, and whenever I place the question before them, whether or not they are convinced of the transmissibility of tuberculosis, some say that no such thing occurs; others, on the contrary, maintain that it does. When I inquire of the latter on what ground their experience rests, they usually tell me stories something like the following. An apparently healthy man, in whose family there is no history of phthisis, marries a woman from a phthisical family. The woman dies, after a few years, with tuberculosis. Soon after her death the man begins to cough, to emaciate, and after several years he also dies with the symptoms of tuberculosis. When I inquire whether another interpretation of these facts would not be admissible, namely: that the man, by being confined to the sick-bed of his wife; by inhaling close air for months in the sick-room—fresh air being mostly cut off in such cases for fear of “catching cold”;—by sleepless and restless nights, and, if he loved his wife, by the mental worry, could be broken down in his health to such an extent that he likewise might become a victim of tuberculosis; most of the physicians admit that such an explanation is admissible. Unquestionably, however, there are physicians thoroughly convinced of the infectiousness of tuberculosis.

Toward the end of the last century, when tuberculosis was greatly prevailing on the European continent, the physicians were pretty well satisfied that the disease was contagious. In Vienna, where there is a great deal of tuberculosis, during the most flourishing period of the medical school, between 1840 and 1865, when the best pathologists and clinicians were teaching, nobody ever thought of the infectiousness of tuberculosis, the disease always being regarded as an entirely constitutional one.

Villemin's experiments, who, with positive results inoculated the sputa of tuberculous men into rabbits and guinea-pigs, created great excitement in Vienna and Berlin; but repeated experiments, chiefly in the latter city, up to 1870, have proved almost conclusively that it is not the material inoculated which renders the rabbits and guinea-pigs tuberculous. Waldenburg, Cohnheim, Fränzel, and a score of others have demonstrated, that under certain conditions in these animals, general tuberculosis could be induced by almost any thing introduced under their skins; for instance, a piece of gutta-percha, sheep's wool, glass-particles, paper scraps, nay, in some cases the slightest injury done to the skin, was sufficient to cause the animals to die of tuberculosis. It was found that rabbits and guinea-pigs, more particularly the latter, were the most favorable objects for experiments; that horses, dogs and rats could be infected only exceptionally; cats never. These animals sometimes died of tuberculosis after injection of finely granular anilin colors into the vascular system, and the tubercles were found crowded with anilin-granules.

In Vienna many experiments were attended with precisely the same results as in Berlin. Rabbits kept in laboratories, in cages, in cellars, and poorly fed, to be sure, promptly reacted after the infection, and were invaded with general tuberculosis. Rabbits, on the contrary, kept in yards,

having plenty of green food at their disposal, and allowed to enjoy fresh air, could be experimented upon in any way, even with inoculation of tuberculous sputa, and, nevertheless, they never showed any signs of tuberculosis; on the contrary, they thrived remarkably and grew fat.

Rabbits and guinea-pigs have usually a poor constitution, this being a characteristic of herbivorous animals in general, viz., the elements of their tissues are finely granular, scantily supplied with living matter. Such animals, if kept in the cellar, after a few days became affected with diarrhoea, which necessarily lowered their constitution still more. Rabbits and guinea-pigs are the most markedly tuberculous of all animals, for with them we rarely succeed in obtaining even regular pus, after operations of any kind; but, as a rule, only a half-dry, crumbly mass, closely resembling the cheesy mass in tuberculosis.

What have all the experiments for the transmission of tuberculosis proved so far? Certainly, that none of the experimenters could be accused of having rendered the animals tuberculous; but that it was the "predisposition" of certain animals, or, as we would express it, their constitution which made them fit, after injuries of any description, for the production of avascular, cheesy, inflammatory masses. Cats are the most unresponsive creatures to these experiments; they never become tuberculous, and their constitution is, as we may easily ascertain under the microscope, really excellent. And, nevertheless, animals of all kinds, apes, elephants, parrots, and even lions die of tuberculosis in menageries, being kept in cages and exposed to all obnoxious influences of the climate. Negroes and mulattoes, who very rarely become tuberculous in the South, often die of this disease after living in the North. Apparently healthy men become tuberculous in prisons; soldiers in the, mostly very unsanitary, caserns, or after having been

broken down by exhausting diseases, such as malarial poisoning, or typhoid fever, or syphilis. Others never die of tuberculosis, no matter what deprivations they may suffer from.

The most striking experiments made in Germany were those in which small quantities of tubercle-matter were transferred into the anterior chamber of rabbits' eyes, and some time afterward tubercles developed in the iris. It was claimed that no other but tubercle matter would produce such a result. Quite recently, however, experiments were made in Vienna, by transferring pus from syphilitic ulcers or vegetations into the anterior chamber of rabbits' eyes, and the result was, as good observers claim, tuberculous iritis.

The experiments have but little value so long as they prove successful only on rabbits and guinea-pigs, and very exceptionally on dogs. If Klebs maintains having rendered animals tuberculous by feeding them with the milk of tuberculous cows; if Rindfleisch claims that every one of us is tuberculous, the difference being that in some the disease breaks out, and in others it does not; and if Billroth asserts that a tuberculous mother makes her baby tuberculous by cleansing its nose with a handkerchief that she had previously used, it certainly takes a certain "predisposition" to make statements of this kind, and, still more, to believe them.

Quite recently Koch, of Berlin, has made the brilliant discovery of a bacillus in the sputa of persons suffering from tuberculosis of the lungs, and characterized by taking up certain anilin dyes (methylen-blue, gentianin, and fuchsin, etc.). He by culture of the bacillus produced its multiplication, and was successful in rendering rabbits, guinea-pigs, and rats tuberculous by inoculation of the fungus. That this bacillus really does exist cannot be doubted, and experi-

ments by Balmer and Fränzel and others have clearly demonstrated that it has both diagnostic and prognostic value: diagnostic, inasmuch as the bacillus is present only in the sputa of persons affected with tuberculosis of the lungs, mostly in its chronic and subacute forms; and prognostic, inasmuch as the disease takes a more rapid course, the more numerous the bacilli in the sputa are. The bacillus was also found in the middle of tubercle-nodules, although it is strange to learn that the numbers are small on the inside of tuberculous cavities, in comparison with the enormous quantities in the sputa. Some claim to have been successful in finding the same bacillus in the dejecta and in the urine, if the corresponding organs were affected with tuberculosis. That the same bacillus with the same reaction with anilin colors was found also in the stagnate water of ditches and pools, will make no serious objection to its pathological significance.

Koch is known to be an extremely skilful and conscientious worker, and the correctness of his assertions cannot be doubted. The results of his experiments, gained by inoculation of the bacillus, are greatly marred by the sources of error alluded to before. We must familiarize ourselves with the possibility that in our bodies, especially in the liquids, there are suspended innumerable germs of the lowest organisms, invisible, to be sure, even to our best modern optical apparatus, and, therefore, hypothetical. The idea of being "sewers of the outer world" is not a pleasant one. The possibility, however, stands, that the germs of, nobody knows, how many different low organisms are floating about in our living organisms, and upon finding a favorable soil for development, at once begin to grow and multiply, and eventually destroy life. There are cases on record in which putrefaction took place in the uninjured articulation of an apparently healthy man; in the pus of osteo-myelitis, micro-

cocci and bacteria were found in enormous numbers; the same in ulcerative endocarditis. All these and many other facts become understood only upon the ground before mentioned. The possibility must be taken into consideration that the low organisms are in no causal relation to the diseases, but simply appear in a secondary way, a certain pathological process, more particularly an inflammatory one, furnishing a favorable soil for their development. It is possible also that the tubercle-bacillus, or rather its germs, come to prosperity only in the cheesy masses so characteristic of tuberculosis, and there is no causal connection between tuberculosis and the bacillus.

In the momentary standing of our experience, the presence of a fungus in tuberculous masses will not explain the fact that some animals are rendered tuberculous with great ease, others only exceptionally, and still others never. Nobody who sees the ravages of the fungus of tinea tonsurans and favus on the skin, will doubt that fungi may produce quite severe inflammations if penetrating the tissues. Here the causal relation between the fungus and the disease is apparent. Not so in tuberculosis. Future experiments and observations will, in all probability, settle the question whether the bacillus is the real cause of tuberculosis, or whether it is a merely incidental occurrence, always, of course, valuable for diagnostic purposes; or whether in animals or men of a poor constitution the fungus causes the inflammation with the disastrous effect of destruction of all blood-vessels and subsequent shrinkage of the constituent elements.

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